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HST Servicing Mission 5 Cost and Risk

Presented to:

Origins Subcommittee (OS)

and

Structure and Evolution of the Universe Subcommittee (SEUS)

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October 23, 2003

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HST Servicing Mission 5 Cost and Risk

Agenda

- SM5 Assumptions
- ROM Cost Estimates
- SM5 Hardware Manifest
- Flight Configuration
- EVA Scenario
- Risk Aspects
- Backup Charts

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HST Servicing Mission 5 Assumptions Baseline Cost Estimate

- **SM5 Launch date April 2010 (Assumes SM4 12/05)**
  - Development period is 52 months
- **Normal (full) science program for Guest Observers (GOs), Guaranteed Time Observers (GTOs), Archival Research, Outreach, and Hubble Fellows operates for 5 years following SM5**
- **Letter contract available for SI pre-award design/dev work**
- **HST instrument heritage assumed for prime SI development cost**
- **PI Science development team included**
- **30% contingency on Science Instrument costs**
- **20% contingency on Servicing Mission development**

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HST SM5 Cost Options and Assumptions

Assumptions	Options				
	Baseline	1	2	3	4
SM5 LRD	4/2010	4/2009	4/2009	4/2009	4/2009
Development Period	52 mos.	40 mos.	40 mos.	40 mos.	40 mos.
New SI	Yes	No	Yes	Yes	No
Science Ops Period	5 yrs.	3 yrs.	3 yrs.	3 yrs.	3 yrs.
SIs Operational	5	2	3	3	2
Science Program					
GOs	✓	No	No	✓	✓
AR	✓	No	No	✓	No
HFs	✓	No	No	✓	No
OPO	✓	No	No	✓	No
GTO	✓	No	✓	✓	No
Science Team		✓			

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HST Servicing Mission 5
Development and Operations/Data Analysis
ROM Cost Estimate - *Baseline*
($M)

Assumptions:

- SM5 LRD 4/2010
- Development period 52 months
- 1 new Science Instrument
- 5 SIs operational
- Full science program for 5 years

		Development[1]	Ops & Data Analysis[2]	Total
FY04 $	OSA[3]	490	389	879
	FCA[4]	586	438	1,024
Real Year $	OSA[3]	551	505	1,056
	FCA[4]	660	568	1,228

Notes:

(1) Covers additive costs in the period from post SM4 mission execution through SM5 execution

(2) Covers all costs in the period following SM5 execution

(3) "Old Style Accounting" - NASA accounting system prior to implementation of Full Cost Accounting in FY04

(4) Full Cost Accounting

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HST Servicing Mission 5 Development and Operations/Data Analysis ROM Cost Estimate - *Option 1* ($M)

Assumptions:

- SM5 LRD 4/2009
- Development period 40 months
- No new Science Instrument or GTO
- No GOs, AR, HFs, or OPO
- 2 SIs operational
- Funding for a science team
- Science Ops for 3 years

		Development[1]	Ops & Data Analysis[2]	Total[5]
FY04 $	OSA[3]	321	155	476 (399)
	FCA[4]	391	179	570 (487)
Real Year $	OSA[3]	357	188	545 (455)
	FCA[4]	437	217	654 (556)

Notes:

(1) Covers additive costs in the period from post SM4 mission execution through SM5 execution

(2) Covers all costs in the period following SM5 execution

(3) "Old Style Accounting" - NASA accounting system prior to implementation of Full Cost Accounting in FY04

(4) Full Cost Accounting

(5) Total costs in parentheses have been reduced by available funding for Science Operations and Data Analysis in FY09 and FY10

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HST Servicing Mission 5 Development and Operations/Data Analysis ROM Cost Estimate - *Option 2* ($M)

Assumptions:

- SM5 LRD 4/2009
- Development period 40 months
- 1 new Science Instrument & GTO team
- No GOs, AR, HFs, or OPO
- 3 SIs operational
- Science Ops for 3 years

		Development[1]	Ops & Data Analysis[2]	Total[5]
FY04 $	OSA[3]	420	164	584 (507)
	FCA[4]	491	187	678 (595)
Real Year $	OSA[3]	465	199	664 (574)
	FCA[4]	545	227	772 (674)

Notes:

(1) Covers additive costs in the period from post SM4 mission execution through SM5 execution

(2) Covers all costs in the period following SM5 execution

(3) "Old Style Accounting" - NASA accounting system prior to implementation of Full Cost Accounting in FY04

(4) Full Cost Accounting

(5) Total costs in parentheses have been reduced by available funding for Science Operations and Data Analysis in FY09 and FY10

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HST Servicing Mission 5 Development and Operations/Data Analysis ROM Cost Estimate - *Option 3* ($M)

Assumptions:

- SM5 LRD 4/2009
- Development period 40 months
- 1 new Science Instrument & GTO team
- 3 SIs operational
- Full science program for 3 years
  - GOs, AR, HFs, and OPO

		Development[1]	Ops & Data Analysis[2]	Total[5]
FY04 $	OSA[3]	420	293	713 (636)
	FCA[4]	491	317	808 (725)
Real Year $	OSA[3]	465	355	820 (730)
	FCA[4]	545	384	929 (831)

Notes:

(1) Covers additive costs in the period from post SM4 mission execution through SM5 execution

(2) Covers all costs in the period following SM5 execution

(3) "Old Style Accounting" - NASA accounting system prior to implementation of Full Cost Accounting in FY04

(4) Full Cost Accounting

(5) Total costs in parentheses have been reduced by available funding for Science Operations and Data Analysis in FY09 and FY10

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HST Servicing Mission 5 Development and Operations/Data Analysis ROM Cost Estimate - *Option 4* ($M)

Assumptions:

- SM5 LRD 4/2009
- Development period 40 months
- No new Science Instrument or GTOs
- 2 SIs operational
- Full science program for 3 years
  - GOs only
  - No AR, HFs, and OPO

		Development[1]	Ops & Data Analysis[2]	Total[5]
FY04 $	OSA[3]	321	249	570 (493)
	FCA[4]	395	273	668 (585)
Real Year $	OSA[3]	357	302	659 (569)
	FCA[4]	440	331	771 (673)

Notes:

(1) Covers additive costs in the period from post SM4 mission execution through SM5 execution

(2) Covers all costs in the period following SM5 execution

(3) "Old Style Accounting" - NASA accounting system prior to implementation of Full Cost Accounting in FY04

(4) Full Cost Accounting

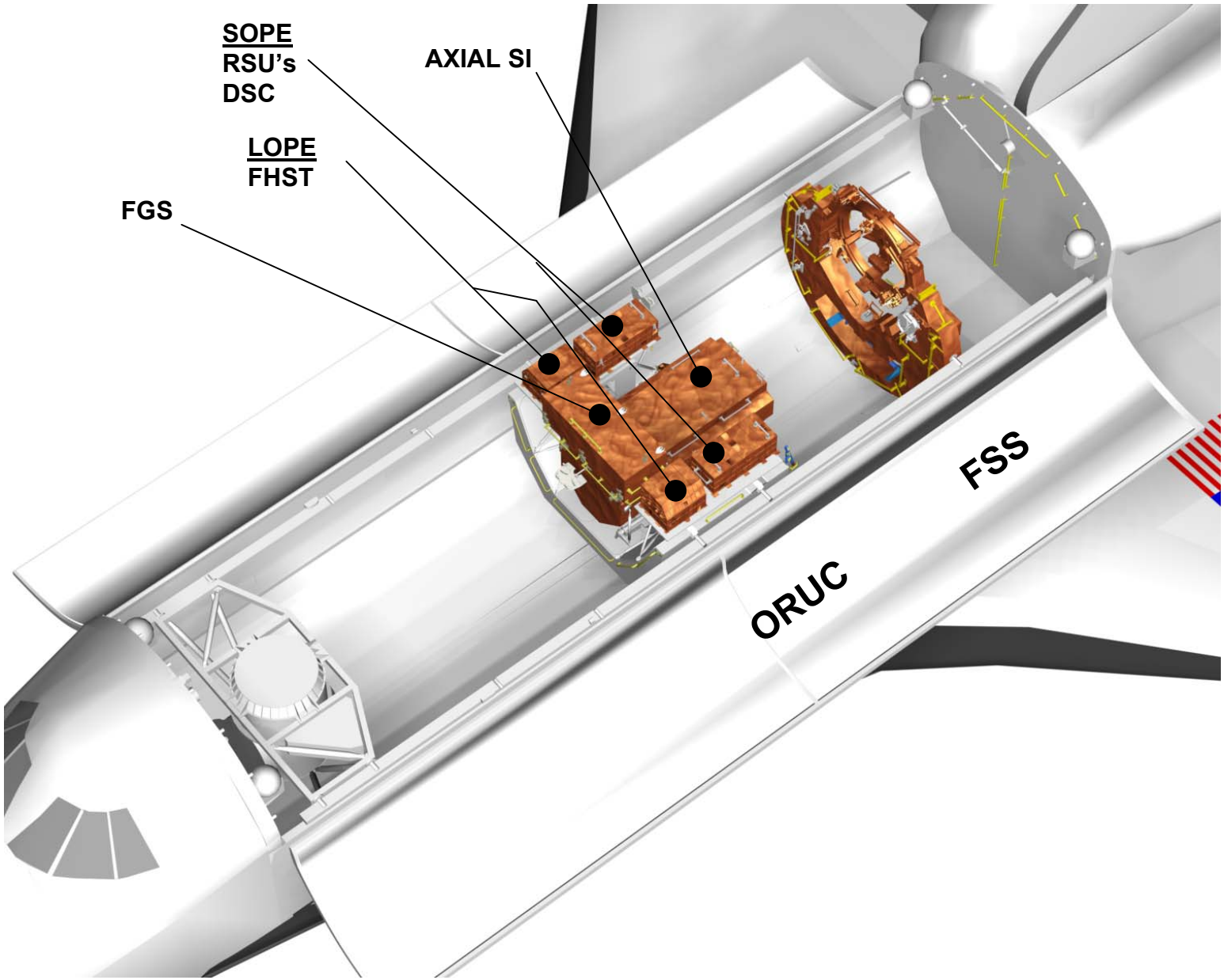
(5) Total costs in parentheses have been reduced by available funding for Science Operations and Data Analysis in FY09 and FY10

HST Servicing Mission 5

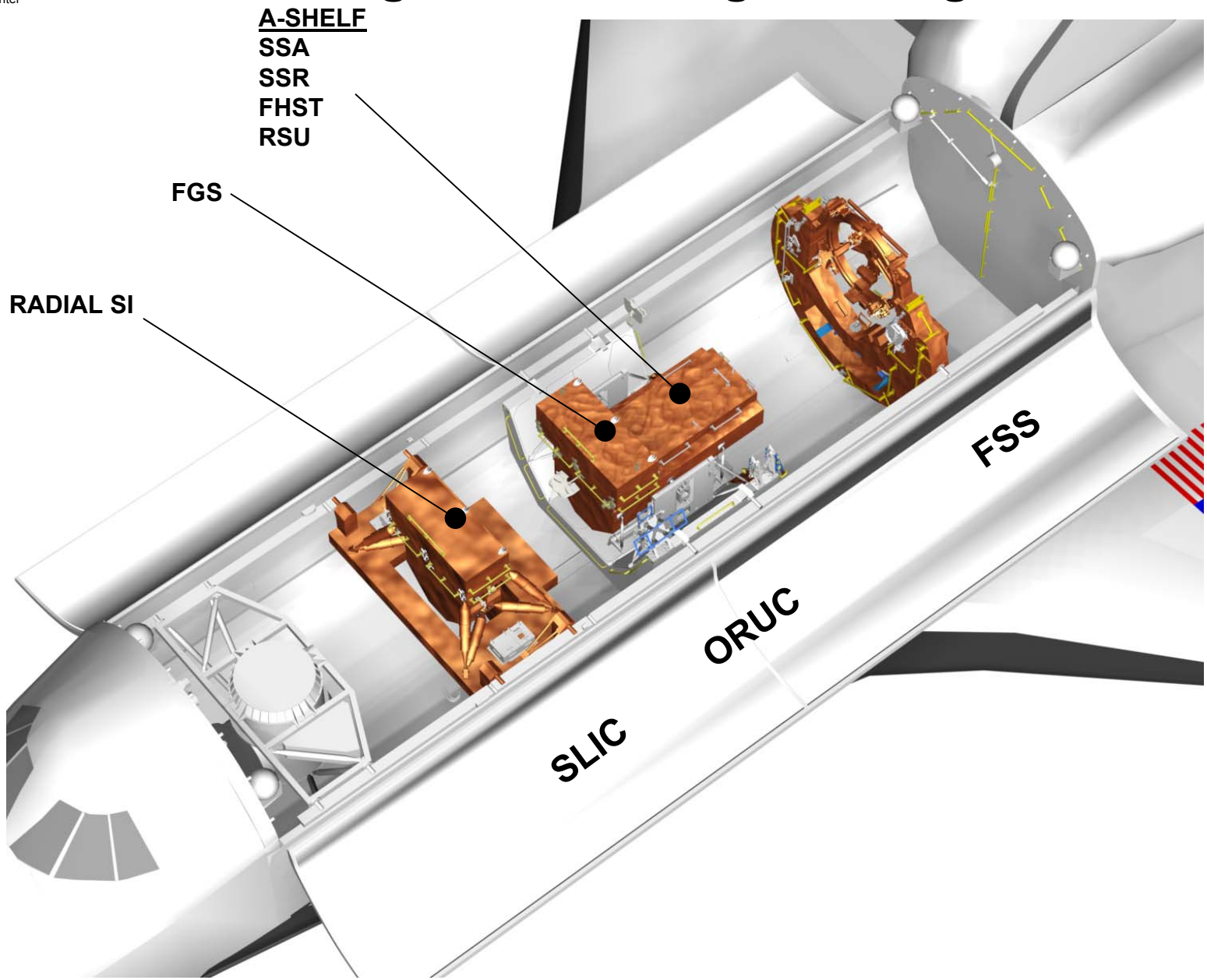
Hardware Manifest

- **6 Gyros**
- **Fine Guidance Sensor**
- **SSA Transmitter**
- **Solid State Recorder**
- **Fix-Head Star Tracker**
- **Carriers**
  - Orbital Replacement Unit (ORU)
  - Flight Support System (FSS)
- **Crew Aids and Tools (CATS)**
- **Reboost**
- **Options**
  - Science Instrument, including Carrier
  - Propulsion Module, including Carrier

HST Servicing Mission 5 Flight Configuration



HST Servicing Mission 5 Flight Configuration



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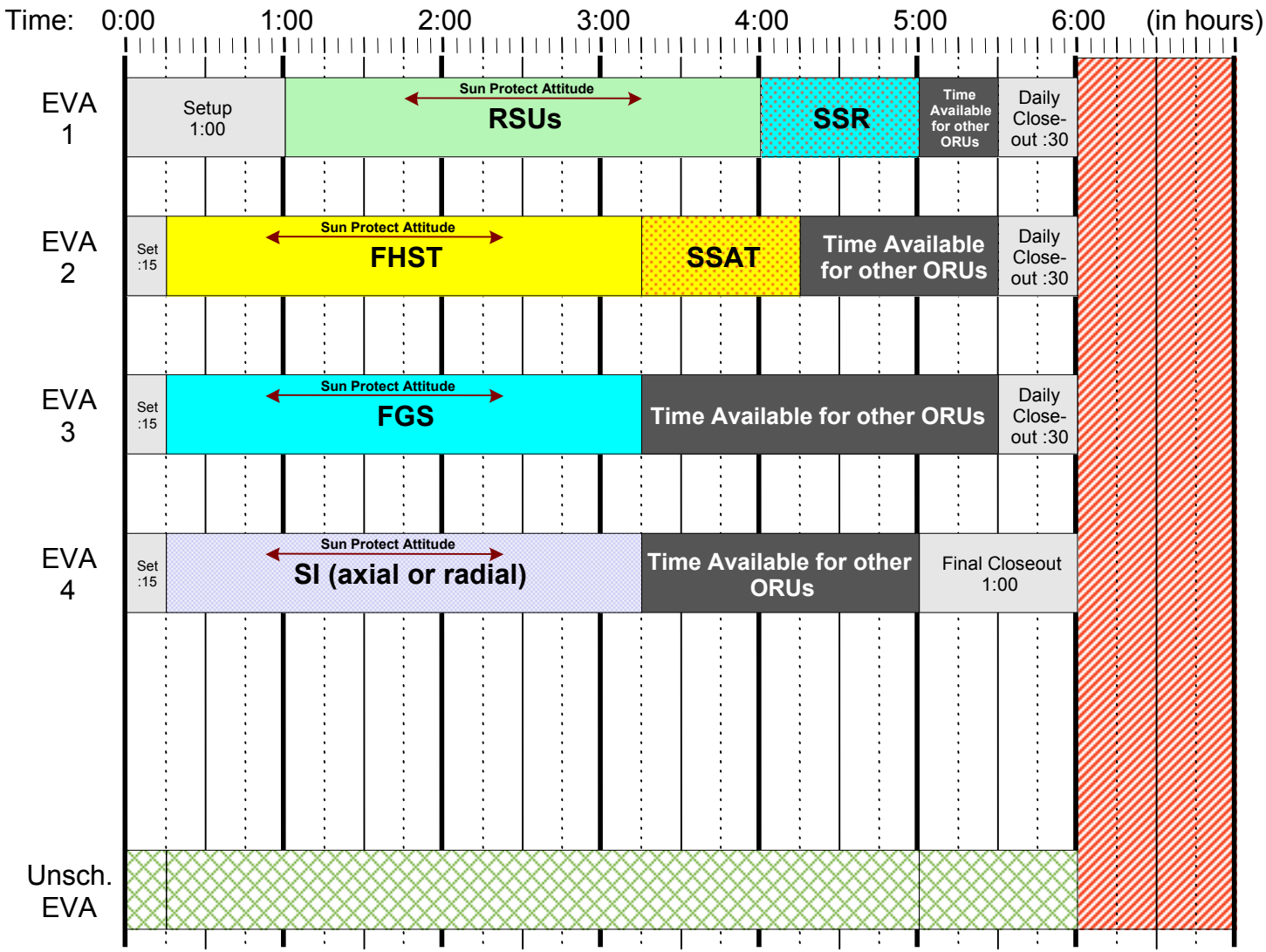
HST SM-5 EVA Scenario
RSUs, FHSTs, FGS, SSR, SSAT and 1 SI



HST SM5 Risk Aspects

HST Program addresses all aspects of each servicing mission for potential risk areas

SM5 Mission Elements

1. **HST Servicing Activities**
   - Servicing Preparations
   - Extra Vehicular Activity
   - HST Deployment
2. **HST SM5 Hardware**
   - Flight hardware installed into HST
   - Space Support Equipment

HST Overall Approach to Risk Mitigation

- Risk mitigation is engrained in HST Program way of doing business
- For SM5, utilize HST formula for success of previous servicing missions
- Utilize HST "Core Team" to take advantage of vast team experience and detailed knowledge of HST subsystems
- Take advantage of existing plans and procedures where servicing of SM5 hardware items has been done on previous servicing missions
- Follow test philosophy of test, test, and retest
- Traditionally low turnover of servicing team personnel facilitates knowledge retention and high level of competency
- HST payload safety process is robust and is considered a model process for NASA
- Lessons learned are captured for each mission and are used to improve processes and procedures

1) HST Servicing

- **Servicing Preparations**
- **Extra Vehicular Activity**
- **HST Deployment**

Risk

- If HST servicing is not successful, then the mission success criteria will not be satisfied or only partially satisfied. The EVA timeline may not be completed. HST health and safety may be jeopardized.

Risk Mitigation

- HST pre-mission verification program assures all mission design requirements are satisfied
- Establish priorities and mission success criteria to guide reduced mission resources decisions
- Conduct Neutral Buoyancy Laboratory simulations to assess mission timeline requirements, optimize mission design, and provide crew training
- Training and Mission Simulation program assures SM5 management team and operations team certified for mission. Assures team is organized and trained to effectively respond to mission anomalies.
- Contingency plans and procedures provide tools to troubleshoot and resolve mission anomalies

2) HST SM5 Hardware

- **Hardware installed into HST**
- **Space Support Equipment**

Risk

- **If the HST SM5 hardware experiences anomalies, then the SM5 mission success criteria may not be satisfied. New hardware capabilities may be lost. Health and safety of HST may be jeopardized.**

Risk Mitigation

- **Flight hardware design and testing enforces the "do no harm" philosophy**
- **Pre-flight testing**
  - Integration and Test program verifies flight hardware and ground system hardware
  - Servicing Mission Ground Tests assure that flight and ground system hardware interfaces are verified. Assures that the planned on-orbit testing is verified against the flight hardware
  - Integrated Hardware Test assures that the entire SM5 mission timeline (5 EVA days) is verified against the flight hardware and ground system
  - Hardware compatibility test assures that the flight hardware and ground system are verified using an operational "flight-like" science timeline
- **On-orbit testing**
  - Conduct Aliveness Tests to assure successful hardware installation into HST
  - Conduct Functional Tests to verify new hardware functionality
- **Contingency Planning**
  - Manifest spare flight hardware items, e.g., spare flight Rate Gyroscope Assembly
  - Provide procedures to troubleshoot and resolve hardware anomalies

Backup Charts

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HST SM5 Instrument Selection and Development Schedule for Baseline Option